Acta Biotheor (2007) 55:91–94
DOI 10.1007/s10441-007-9012-y

BOOK REVIEW

Sahotra Sarkar, Molecular models of life: philosophical papers on molecular biology

MIT Press, Cambridge, MA, 2005, xvi + 396 pp, (Hb) ISBN-10: 0-262-19512-7, ISBN-13: 978-0-262-19512-6, $38.00; (Pb) ISBN-10: 0-262-69350-X, ISBN-13: 978-0-262-69350-9, $25.00

Daniel Sirtes

Accepted: 12 April 2007 / Published online: 5 June 2007

Sahotra Sarkar, who holds a double appointment in philosophy and integrative biology at the University of Texas at Austin, is one of the most prolific authors in philosophy of biology and adjacent disciplines.[1] His creativity and productiveness can be compared to Paul Feyerabend's.[2] However, the somewhat unfortunate selection of papers in *Molecular Models of Life. Philosophical Papers on Molecular Biology* seems to suggest two further similarities between their respective works, redundancy and mixed quality. This compilation of articles on the philosophy of molecular biology, of which all but one were previously published between 1988 and 2003, harbors such gems as a wonderful introduction into the reductionism debate, (chapter 2), a poignant critique of the information metaphor in biology (chapter 9) and very illuminating historical-philosophical treatises about directed mutations (chapter 12) and the rise and fall of the importance of genes in the last century (chapter 14). However, these must-reads are surrounded by superfluous truncated versions of these papers (chapters 4, 8, 11) and some papers with relatively few new insights, which will probably leave many readers unimpressed.

The book is divided into four parts that order the papers into four major topics: reduction, function, information, and evolution. The first paper of the reduction section (chapter 2) is both a historical and systematic analysis of the reductionism debate. Sarkar classifies different models of reduction, i.e. different views of what a successful reduction would amount to, into three categories of reductionism: Theory reduction, explanatory reduction, and constitutive reduction. If a model of reduction is construed as a relation between theories, it falls under theory reduction. If it is construed as a form of explanation, it is in the explanatory reduction category. And

[1] Rumor has it that Sarkar works at any given time on forty different papers simultaneously.

[2] See Oberheim (1999) for a full bibliography of Feyerabend's works.

D. Sirtes (✉)
Science Studies Program, University of Basel, Missionsstrasse 21, CH-4003 Basel, Switzerland
e-mail: daniel.sirtes@unibas.ch

if reduction involves the ontological claim that higher-level phenomena are consistent with or constituted by lower-level phenomena, it can be called constitutive reduction. This kind of disambiguation, although not new,[3] is a very helpful tool for readers interested in an introduction to the topic. Sarkar explicates eight different models of reduction, in a concise and lucid way, and orders them into the respective categories. (Only the classic Nagelian model of theory derivability falls under all three of them. Fodor's consistency model and Hull's supervenience model claim only a constitutive reduction, etc...). In the last sections of the paper, Sarkar applies the models to molecular biology. Although this part is quite short and questions about the reduction of classical genetics to molecular biology (a diachronic *and* inter-level reduction) are intermingled with questions about reduction of biological phenomena to molecular biology in general (only inter-level reduction), it still offers a helpful introduction that explains what all the fuss about reductionism is about. Sarkar also introduces his own model of reduction, but this summary is too short to be comprehended fully. Unfortunately, the expectation that the following chapters will extend on it is frustrated. Readers interested in his take on reduction must be redirected to Sarkar's (1998) book *Genetics and Reductionism* (Sarkar 1998). In chapter 3, Sarkar rejects genetic reductionism, meaning the explanation of the production of phenotypes on the basis of classical genetics. He claims however, that ''leaving ecology aside, it is [...] hard to imagine how the future of biology can be anything but molecular.'' This kind of *physical reduction*, i.e., the explanation of biological phenomena on the basis of molecules and their interactions has surely been one of the great success stories of science in the last 50 years. However, considering that Sarkar is cautious enough to reprimand us that the ''exploration of nonreductionist research strategies is [a] way to test the limits of physical reductionism'' that deserves more support, it is hard to imagine against whom he could possibly be arguing.

In the section about function, there are two chapters that complement each other well. In chapter 5, Sarkar adopts Bill Wimsatt's explication of functional explanation in biology, which involves two causal theories, a chemical theory and a selection theory. The first theory specifies the effect of a certain property, while the second must establish that this effect enhances the fitness of the carrier of that property. Then the effect can be called the function of that property. Only the two theories together can give a *functional explanation* of a certain feature of an organism. Sarkar claims further that functional explanations cannot be adequate when offered as answers to questions of mechanism. They can only be offered in response to questions of origin. He argues that a functional explanation that only determines the causal role of a property in a mechanism is ''gratuitous and unnecessary'' invocation of function as merely stating the effect of that property would be enough. However, why one could not have several notions of function *and* of functional explanation is unclear. One could answer questions of origin and involve fitness, adaptation, or persistence, and the other could denote the part of the effects of a certain property that is crucial in bringing about a certain biological phenomenon of interest. Although this kind of causal-role-functional explanation

[3] A quite similar classification can be found already in Ayala (1974).

has a pragmatic aspect, as it is dependent on the phenomenon one wishes to explain, it is widely used in molecular biology.[4] Sarkar concludes this chapter by asserting that as long as the theory of natural selection is incapable of physical and chemical explanations, functional explanations—as he reconstructs them—cannot be viewed as instances of any kind of reduction. Even so, in the next chapter Sarkar seeks exactly this kind of physical warrant of a selection theory. Expanding on Manfred Eigen's theory of hypercycles, he exposes the possibilities and limitations of a physical theory of natural selection in a precise and fascinating way.

Turning to information, Sarkar's 1996 paper about the central dogma(s) of molecular biology and information (chapter 9) can already be considered a modern classic in the philosophy of biology. There, he argues that the notion of information in molecular biology is ''little more than a metaphor that masquerades as a theoretical concept and, [...] leads to a misleading picture of the nature of possible explanations in molecular biology'' (p 206). This provocative claim is meticulously argued for and should be read by anyone interested in theoretical biology. However, whether recent developments in bioinformatics and systems biology have made such a progress on the concept of information and its fruitful application that Sarkar's arguments can be regarded as obsolete is not for me to answer.

In a somewhat awkward change of heart, Sarkar attempts in the following chapter (first published in 2004) to explicate his own (very) technical notion of information, a 'semiotic information concept'. What is particularly odd is that the same person who writes that ''[w]hat is mysterious is why information theory—or any abstract theoretical framework—has to be invoked to make so trivial a point'' (p 196) goes through so much laborious explication only to arrive at conclusions such as that although eukaryotic genes carry information for proteins, this information is insufficient for specifying a particular protein; or that the two questions of whether genes should be viewed as carrying information and the relative influence of genes versus nongenetic factors in the etiology of traits are entirely independent. This is mysterious indeed.

In the final part of the book, treating evolution, Sarkar exhibits his true mastery. Combining his extensive knowledge of the history of biology, his intimate understanding of biological problems and a brilliant mathematical mind, he tackles the problem of directed (directional) mutations[5] with great conceptual precision and fruitful results. Contrasting a viable conception of Neo-Lamarckism with the claims of Neo-Darwinism, he reconstructs the subtleties of the experimental and mathematical aspects of Luria and Delbrück's 'fluctuation test' (1943) and the subsequent research until today. He shows that in some cases, Neo-Lamarckist hypotheses do not contradict Neo-Darwinism. Moreover, although Sarkar himself played a role in the mathematical analysis and generalization of the Luria-Delbrück-distribution (Sarkar et al. 1992), he contends that only a mechanistic, reductionist

[4] See e.g. Walsh and Ariew (1996) and Wouters (2003) for such a pluralistic approach to the notion of functions.

[5] That is the question whether there are cases where the environment can be responsible, directly or indirectly, for the genesis of variations that are adaptive to it.

methodology can resolve the issue of the extent and the kind of specific models that fall under the phenomenon of directional mutation.

This book does not exhibit a grand synthesis of the philosophy of molecular biology. However, it is doubtful whether such a goal is attainable or even desirable. Together with Schaffner (1993) and Weber (2004), which all have this kind of fragmented but comprehensive look at the philosophical problems arising through experimental biology, Sarkar's book is a welcome addition to this fascinating and emerging field in the intersection of philosophy, history, molecular and theoretical biology.

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